

## ABSTRACT

2 The invention utilizes harmonics of certain clamped ultrasound transducers to generate  
3 ultrasound within the liquid of an ultrasonic tank and in a frequency range of between about  
4 100khz to 350khz (i.e., "microsonic" frequencies). The application of microsonic frequencies to  
5 liquid preferably occurs simultaneously with a sweeping of the microsonic frequency within the  
6 transducer's harmonic bandwidth to reduce or eliminate (a) standing waves within the liquid, (b)  
7 other resonances, (c) high energy cavitation implosion, and (d) non-uniform sound fields, each of  
8 which is undesirable for cleaning and/or processing of semiconductor wafers and other delicate  
9 parts. The invention can also drive ultrasonic transducers such that the frequency of applied  
10 energy has a sweep rate within the ultrasonic bandwidth of the transducers; and that sweep rate is  
11 also varied so that the sweep rate is substantially non-constant during operation. This reduces or  
12 eliminates resonances which are created by transducers operating with a single sweep rate. An  
13 ultrasound generator of the invention sometimes utilizes amplitude modulation (AM), and the  
14 AM frequency is swept over time so as to reduce resonances. AM control is preferably provided  
15 by selecting a portion of the rectified power line frequency. In applications which utilize  
16 multiple generators, multiple transducers, and one or more tanks, simultaneously, the invention  
17 synchronizes the operation of the generators to a common FM signal to reduce beat frequencies  
18 between generators. Each such generator can also be adjusted, through AM, to control the  
19 process characteristics within the associated tank. Two or more transducers are sometimes used  
20 by the invention, in combination, to broaden the overall bandwidth of acoustical energy applied  
21 to the liquid around the primary frequency or one of the harmonics. The bandwidths of the  
22 transducers are made to overlap such that an attached generator can drive the transducers, in  
23 combination, to deliver ultrasound to the liquid in a broader bandwidth. In a single chamber  
24 ultrasound system, two or more generators, each operating or optimized to generate a different  
25 range of frequencies, are connected to a multiplexer; and the desired frequency range is selected,  
26 and hence the right generator, according to the cavitation implosion energy that is desired within  
27 the tank chemistry.